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ABSTRACT

This guide accompanies a compact disk that provides a comprehensive collection of information resources. The compact disk is organized according to energy sources and cross-referenced to issues that must be considered when making decisions about energy. This booklet, designed around questions common to high school students, illustrates how the compact disk can enable students to find answers to their questions and form opinions based on facts. The activities directly support the content and pedagogy in science curricula that address the need for more students to study science and for all students to develop scientific literacy. The six activities focus on the use of renewable resources and the effects on society. Activities are the following: "What Is Renewable Energy?"; "Why Do We Need Options?"; "What Is Energy Efficiency?"; "What Is the Environmental Cost of Energy?"; "How Can Passive Solar Be Used in Home Construction?"; "How Can Motor Vehicles Use Renewable Energy?" (DDR)

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ED 421 361

Six Activities On Renewable Energy And The Environment
Plus An Introduction To The Sun's Joules CD-ROM

THE SUN'S JOULES

RENEWABLE

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RENEWABLE ENERGY

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The Sun's Joules CD-ROM

The Sun's Joules CD-ROM is a comprehensive collection of information resources developed by the Center for Renewable Energy and Sustainable Technology (CREST), funded by the U.S. Department of Energy and directed by the National Renewable Energy Laboratory (NREL). *The Sun's Joules* provides access to accurate information about new technological advances in utilizing energy resources efficiently and responsibly. The CD-ROM is organized according to energy sources, and cross referenced to issues that must be considered when making decisions about energy. Information is presented through video, audio, photos, text, and interactive exercises. *The Sun's Joules* CD-ROM runs on Macintosh and Windows-compatible computers.

To help teachers utilize *The Sun's Joules* CD-ROM in middle and high school classrooms, the U.S. Department of Energy funded the Mid-continent Regional Educational Laboratory (McREL) to develop teacher resource materials under the direction of NREL. *The Sun's Joules* Energy Education Program Guide features a problem-based unit in which students learn how to apply information from the CD-ROM to energy use issues faced by today's society. Additional information about the McREL resources that support *The Sun's Joules*, including professional development workshops can be found on the inside back cover of this booklet.

To order copies of
The Sun's Joules CD-ROM
Classroom Edition $59.95,
Lab Pack of 8 $199.95
Call The Learning Team at
1-800-793-TEAM

"Everyone needs to use scientific information to make choices that arise every day. Everyone needs to be able to engage intelligently in public discourse and debate about important issues that involve science and technology."

National Science Education Standards page 1

WHAT IS RENEWABLE ENERGY?

An Introduction To The Sun's Joules CD-ROM and Energy Education Program

Written by
Joyce Lowry Weiskopf, Ph D.

Produced with funding from the
U. S. Department of Energy,
Office of Energy Efficiency and Renewable Energy

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Introduction

Almost daily, we are confronted with issues about energy that require decisions. Should I drive or ride a bicycle? Should I leave the computer on overnight? Will a heat pump reduce my monthly electric bill? Which is the most energy efficient car? Should I support construction of a new dam for a hydroelectric plant?

Issues resulting from our need for energy have received much attention in the media. Debates and discussions about depletion of our natural resources and pollution are common in the news and among politicians. Which are opinions? Which are facts? We hear about the need for alternative fuels, use of renewable resources, and demands for energy efficiency. New technologies are continually being researched and developed. But are they cost effective? Which is best for our community? How do we know they are safe?

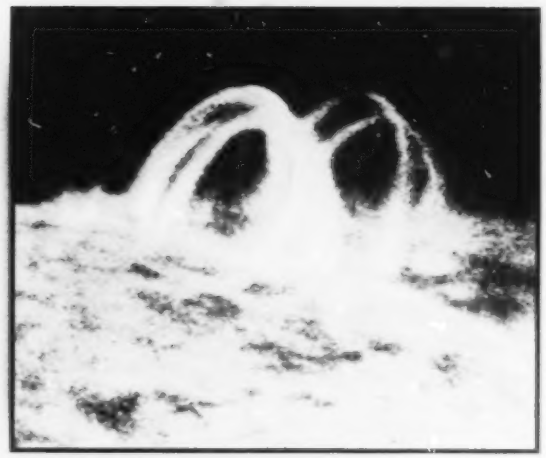
Most high school students have opinions about energy — opinions based mainly on what they have heard. However, many of these students still have naive ideas about the interactions among science, policy, and society and may not be aware that all sources of energy have benefits and costs to the consumer, the community, and the environment. Consideration of the tradeoffs between costs and benefits is a vital aspect of decision making.

> *"The concepts of the world that students bring to school will shape the way they engage in science investigations and serve as filters for their explanations of scientific phenomena. Left unexamined, the limited nature of student beliefs will interfere with their ability to develop a deep understanding of science."*
>
> *National Science Education Standards page 174.*

Students develop the concept of tradeoffs over time and through classroom discussions and activities which do not present decisions as right or wrong, but as negotiated compromises. This type of activity depends on accurate information and promotes scientific literacy — the knowledge and understanding of science and technology that enables us to learn, reason, and think creatively to solve problems. *The Sun's Joules* CD-ROM provides an easily accessible source of accurate information; the accompanying instructional materials enable teachers to facilitate learning about renewable energy and energy efficient technologies in a manner that can lead to informed decisions.

This booklet, designed around questions common to high school students, illustrates how *The Sun's Joules* can serve as a valuable resource, that enables students to find answers to their questions and form opinions based on facts. The activities in this booklet also directly support the content and pedagogy in Standards-based science curricula that address the need for more students to study more science and for all students to develop scientific literacy.

What Are the Sun's Joules?



Surface of the Sun

A joule is a metric unit used to measure energy and is equal to a watt, or approximately one-fourth of a calorie. A joule of work can move one kilogram the distance of one meter in one second. A joule of heat can raise the temperature of one kilogram of water one degree centigrade. This unit is named for the British physicist James Prescott Joule who lived in the 1800s.

The sun is our major source of energy. The sun's joules are the output of the sun's nuclear fusion reactions. The amount of solar radiation that reaches the surface of the Earth varies during every day and by location. Overall, more solar energy falls to the Earth in one day than the total amount of energy the planet's 5.7 billion inhabitants would consume in 27 years.

What Is Energy?

The word energy is used several ways. Energy is the ability to perform work. Kinetic energy is the energy of moving objects and can be transferred from one object to another. Chemical energy is energy stored in matter that can be released to do work, as the energy in coal before it is released through burning. Energy can be transferred, converted, or released in many ways and in different forms, including light, heat, sound, and electricity. Energy, however, cannot be used up.

Power is the term for the rate of energy use, transfer, and production, and is measured in terms such as kilowatts, horsepower, or calories per second. In our day-to-day lives, we frequently use the word energy to refer to the matter, or fuel, from which useable forms of energy can be generated. These fuels, or sources of energy, can be used up as they provide the power to light our streets, fuel our cars, or heat our homes. Energy, in this context of resources that can be used to generate power, is the focus of this booklet.

What is the Cost of Energy?

As our country continues to grow and become more technologically based, our dependency on all forms of energy, especially electricity and transportation fuels, will continue to grow. Each year, Americans spend nearly half a trillion dollars for energy services. Much of the power we use daily is generated from burning fossil fuels — coal, oil, and natural gas. But the source of fossil fuels is finite. At our current rate of consumption, the reserves of some fossil fuels may be depleted within fifty years.

We must face the fact that generating electricity and other forms of energy have both direct and indirect costs. The cost to generate power includes more than the just the cost of obtaining and processing the fuel source; it includes the cost of the technology and maintaining the facility, as well as the system for delivering the power. The cost of energy consumption also includes cost to the environment.

Economics Page 71, Sun's Joules CD-ROM

There is a close connection between production and consumption of energy and pollution. The cost of pollution is quickly becoming obvious to all; air pollution is directly related to an increase in lung disease, asthma, and heart conditions. There are other environmental costs, notably the depletion of resources. Cutting trees for fuel and the erosion caused by strip mining are highly visible; less obvious is the depletion of oil and natural gas.

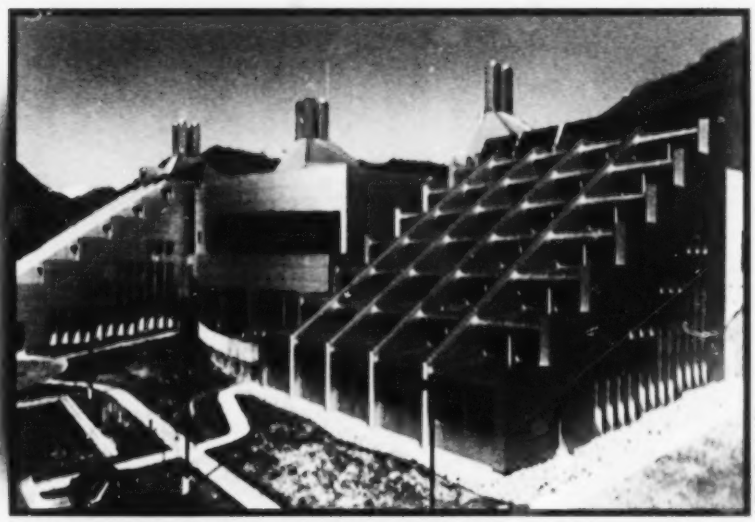
Economics related to energy is not only about cost, it is also about risk and uncertainty. One risk that must be considered is the one to human life. This was demonstrated by the nuclear accident at Chernobyl. Another risk is the harming of wildlife, as illustrated in Alaska after the Exxon Valdez oil spill. Concerns still exist about electromagnetic fields. Each new technology has risks that must be anticipated and considered in discussions about cost.

Growing energy demands, increasing environmental problems, and declining fossil fuel resources have made us look to alternative energy options. Opinion surveys consistently show that the majority of the public prefer renewable energy and energy efficiency over other energy alternatives, and want renewable energy technologies to comprise an increasingly larger portion of the nation's energy mix.

What Are Renewable Sources of Energy?

Renewable energy is a phrase that encompasses many diverse resources – wind, water, solar heat and light, biomass, and geothermal energy. New technologies to convert this free energy are continually being researched and developed. Some have proven to be cost-effective for centuries, while others require more research and development before they become commercially feasible.

Diversity is a key factor in the U.S. Department of Energy's policy; diversity in sources and in the technologies that convert sources to useable energy. DOE is committed to investigating renewable sources of energy and the development of efficient and sustainable technologies to make energy accessible and economical.



The National Renewable Energy Laboratory

The National Renewable Energy Laboratory in Golden, Colorado is the world leader in renewable energy technology development. Since it opened in 1977, NREL's sole mission has been to develop renewable energy technologies and transfer these technologies to the private sector. NREL's solar energy research facility, constructed in 1994, utilizes technologies that illustrate the advances that have been made.

In the past two decades, a DOE investment totaling about $1.1 billion in energy-efficient industrial technologies has yielded approximately $2.5 billion in documented energy savings and net productivity gains. The accumulation of these savings continues to grow at increasing rates. By the year 2000, these investments will be generating a savings of about $10 billion a year. Very few other federal investments produce as great a societal return on the taxpayers' dollars.

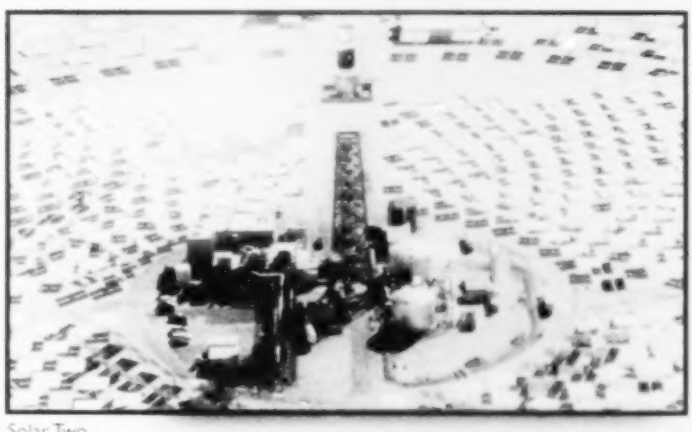
Solar Energy

Anazasi cliff dwelling

Energy from the sun is the physical source of all renewable energy flows on earth. The challenge is to capture and convert the light and heat portions of the energy spectrum into useable energy. Passive solar is one of the oldest strategies for utilizing renewable energy and has been used effectively for thousands of years. Buildings that take advantage of passive solar heating and cooling must rely on a diverse range of science concepts, engineering practices, and architectural designs.

The strategies for preventing excess solar radiation during hot summers are not the same as the strategies for maximizing solar radiation for heat in the winter. Knowledge and understanding of the environment is a critical factor in constructing energy-efficient passive solar buildings.

The primary solar energy technologies include photovoltaics, solar thermal electric systems and solar heating and cooling systems. All of these capture the sun's energy to produce electricity or heat. Photovoltaic solar cell systems, or PV systems, generate electricity from sunlight and are one of the fastest growing solar energy technologies. PV cells, commonly called solar cells, use semiconductor material to convert sunlight directly into electricity. Solar cells have no moving parts —power is produced when sunlight strikes the semiconductor material and creates an electric current. They give off no pollution during operation.



Solar Two

PV's in the jungle

Another use for solar thermal systems is to detoxify soil.

Photovoltaic cells today are able to convert between 5 and 15 percent of the energy in sunlight into useable energy. The efficiency of photovoltaic cells is constantly increasing as new materials and manufacturing processes are developed. In 1955, Bell Laboratories invented the first practical PV cell; by 1995, they cost one tenth what they did in 1975. PV systems have the potential to bring electricity economically to the billions of people living in remote regions of the Earth that now have no access to electricity.

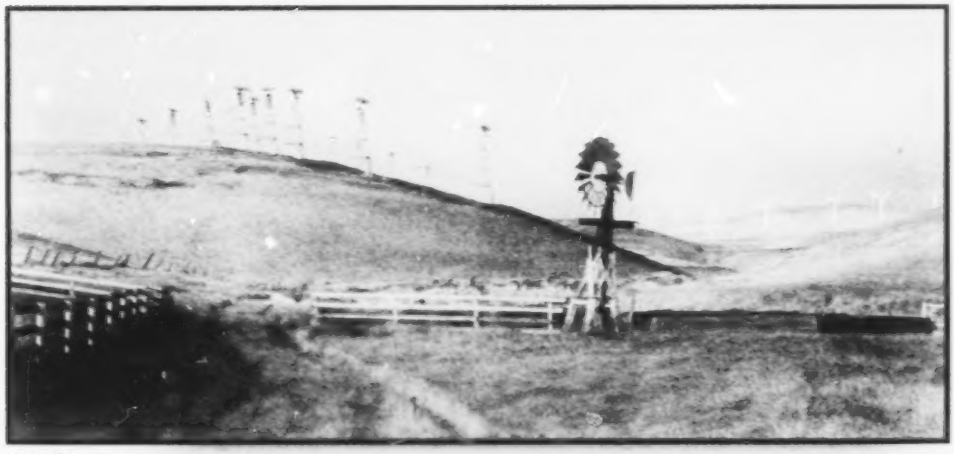
Unlike solar cells, which use light to produce electricity, solar thermal electric systems generate electricity with heat. Concentrating solar collectors use mirrors and lenses to concentrate and focus sunlight onto a receiver mounted at the system's focal point. The receiver absorbs and converts sunlight into heat. The heat is then transported to a steam generator or engine where it is converted into electricity. The heat from solar thermal collectors can also be used directly for hot water heating and other thermal applications.

Solar energy technologies offer a clean, renewable, and domestic energy source. Power generating systems are also modular, meaning they can be constructed to meet any size requirement and are easily enlarged to meet changing energy needs.

Wind Energy

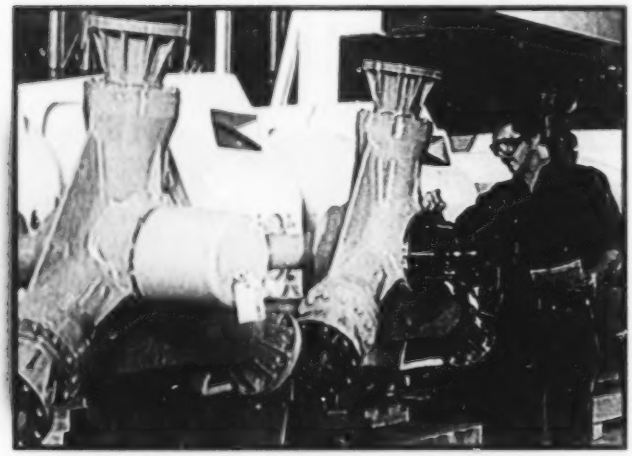
Windmills have been used for centuries as a way to harness energy from the wind to pump water and grind grain. The use of wind involves the conversion of kinetic energy contained in moving air masses to mechanical power through rotating shafts. Wind turbines are now one of the most promising renewable sources of electric power.

NREL PIX 00643



Windfarm

The wind turbines that were rushed to market in the 1970s had problems, such as noise and TV interference, that have largely been solved. With the DOE's help, the old wind-turbine blades, borrowed almost directly from aircraft-propeller design, have been replaced with sophisticated blades designed to capture wind energy efficiently over a broad range of wind speeds and direction. Over the past fifteen years, electricity from wind power has declined in cost by 10 percent per year. Utilities are already receiving long-term bids for electricity from wind at 4.5 cents per kilowatt-hour in the best wind sites in the country. With a continued public-private partnership in technology advancement, wind could hit three cents per kilowatt-hour by 2020, and soon after that, wind-power plants' annual sales could reach $50 billion.



NREL PIX 01467

Wind turbine engine

Energy from Biomass

Biomass is the term used for the wide range of biological resources that can be converted into energy. Burning wood for light and heat is one of the oldest and most obvious uses of biomass. Using wood chips and other wood waste products is a newer strategy for converting biomass into energy.

NREL PIX 00594

Walnuts used for burning

One of the most promising uses for biomass is the development of biofuels. When biomass is converted into biofuels, the carbon dioxide released is recaptured by new plants through the process of photosynthesis. Currently, ethanol, made from corn, is one such biofuel. DOE research is now advancing the production of ethanol from cellulose biomass such as wood and grasses.

In 1994, research sponsored by the DOE created a genetically engineered organism that enhances the fermentation of cellulose, increasing the rate of conversion and the yield of ethanol. This has sparked new commercial interest in this process, which may greatly expand the availability of biofuels in the United States. Fuel cells are another technology developed to utilize biomass. These are compact modular devices that generate electricity and heat with high efficiency and virtually no pollution. Fuel cells transform chemicals directly into electricity with no moving parts and without combustion. By eliminating the need for combustion to produce heat – the step that produces the most waste products – fuel cells can greatly reduce air pollution.

NREL PIX 04979

Scientist with biofuels

Geothermal Energy

NREL PIX 00063

The Geysers, Calistoga, California

Beneath the Earth's surface lies one of the world's largest energy resources — geothermal energy. Our ancestors have used geothermal energy for cooking and bathing since prehistoric times. Today, this enormous energy reservoir supplies millions of people with clean, low-cost electricity.

Hydrothermal reservoirs are large pools of steam or hot water trapped in porous rock. To create electricity, the steam or hot water is pumped to the Earth's surface, where it drives a turbine that spins an electric generator. Because steam resources are rare, hot water is the resource for most geothermal power plants.

Geothermal power plants use wells to pipe steam and hot water trapped underground to the surface to make electricity. Currently, U.S. geothermal power plants power the homes of more than 3.5 million people. The power plants produce electricity at 3 to 7.3 cents per kilowatt-hour.

Earth energy — the heat contained in shallow ground — is used directly to heat or cool homes and commercial buildings through "direct-use" technologies such as geothermal heat pumps (GHP) and district heating systems. GHPs use the Earth's relatively constant ground temperature to provide low-cost heating and cooling. In the winter, GHPs transfer heat from the ground into homes and buildings. In the summer, GHPs cool homes and buildings by transferring indoor heat into the ground. GHPs can cut heating costs by 30 percent and cooling costs by 25 percent.

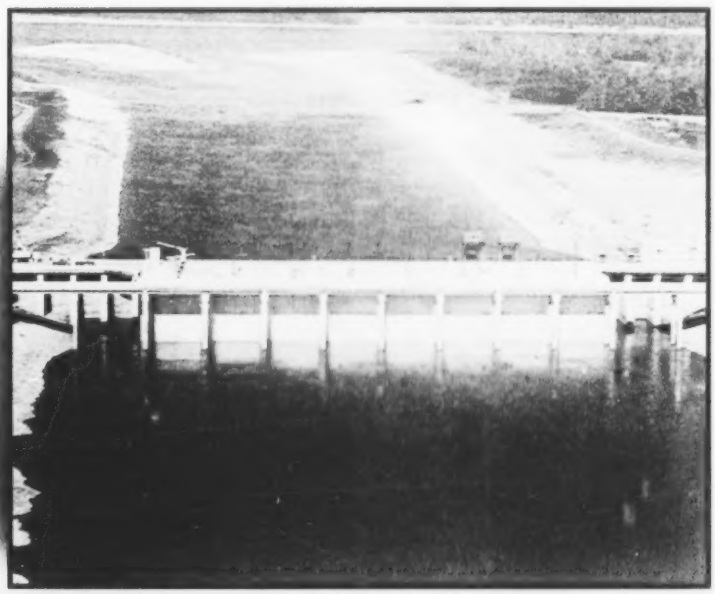
Geothermal energy offers an environmentally benign source of electricity and is highly reliable. Hydrothermal reservoirs and earth energy are currently used commercially. To use the other three forms — geopressured brines, hot dry rock, and magma — advanced technologies must be developed.

NREL PIX 01044

Dry steam geothermal power plant

Energy from Water

Since the time of ancient Egypt, people have used the energy in flowing water, hydropower, to operate machinery and grind grain and corn. In the 19th century, understanding of electromagnetic principles were applied to develop technology that converts the mechanical energy from water flowing over a waterwheel to produce electricity. Today, hydropower produces 24 percent of the world's electricity, and 9 percent of the United States', accounting for almost half of the renewable energy used in the United States.



NREL PIX 03909

Hydroelectric Plant

Hydropower plants provide inexpensive electricity and produce no pollution. Unlike other energy sources such as fossil fuels, water is not destroyed during the production of electricity — it can be reused for other purposes. Most hydropower plants are built through federal or local agencies as part of a multi-purpose project. In addition to generating electricity, dams and reservoirs provide flood control, water supply, irrigation, transportation, recreation, and refuges for fish and birds.

However, American rivers and watersheds are being overtaxed by these multiple demands. A large number of freshwater organisms are becoming endangered. Science's lack of knowledge about aquatic organisms, especially micro-invertebrates, increases the concern for any changes in river habitats. Large hydropower plants can significantly impact the surrounding area. Reservoirs affect not just fish and wildlife habitat, but can cover towns, scenic locations, and farmlands.

Small-scale hydropower is an alternative that is now being utilized to capitalize on the advantages of the use of water as a source of energy, while minimizing the negative impact on the environment.

Activity Summary

The following activities provide examples of how *The Sun's Joules* CD-ROM can support problem-based learning experiences within the high school classroom.

Activity 1: What Is Renewable Energy? . . . . . .Page 13
Daily energy use is used to introduce the issues surrounding finite resources commonly used to generate energy and the use of renewable sources of energy. This activity is appropriate for use in high school physics to engage students in exploring conservation of energy and increase in disorder, interactions of energy and matter, natural resources, environmental quality, and science and technology in local, national, and global challenges.

Activity 2: Why Do We Need Options? . . . . . .Page 15
Learning which fuels are used to generate power in their own state sets the stage for role play that reflects opposing points of view on potential changes in fuel sources. This activity provides students with the opportunity to apply understanding of geography and economics to science and technology in courses such as Active Physics, Biology in the Community, Chemistry in the Community, Government, and Civics.

Activity 3: What Is Energy Efficiency? . . . . . .Page 17
Investigating the rate of energy use provides a review of units used to measure energy. Comparing the cost to produce energy to the percentage of useable power obtained provides the focus for discussion on efficiency and how value can be determined. This activity can be incorporated into Active Physics: Home, which addresses electricity use in the home and the generators that supply the electricity. Other appropriate uses for this activity include application of percentages, maximization theories, and data analysis in mathematics as well as energy transfer and changes in matter in a physics course.

Activity 4: What Is the Environmental Cost of Energy? . . . . . .Page 19
Beginning with their own concepts and misconceptions about pollution and environmental impact of energy production, students research the problems, then discuss how renewable energy can provide solutions. Determining the difference between fact and opinion, analyzing potential bias in the data, and reflecting on what they learn enables students to apply information to their own consumption of energy. This activity supports the concepts of interdependency among organisms and their environment that are included in science courses such as Chemistry in the Community, Biology in the Community, and many environmental education programs.

Activity 5: How Can Passive Solar Be Used in Home Construction? . . . . .Page 21
An experiment from Active Physics: Home, in which students collect data on the rate of temperature increase inside a cardboard home they have designed and constructed. Discussing peak temperature leads them to research passive solar technologies they can use to make their home cooler in the summer, while maintaining heat on colder days. This activity can also be used as an application problem in a mathematics class using graphing calculators to study data analysis.

Activity 6: How Can Motor Vehicles Use Renewable Energy? . . . . . .Page 23
Fuel economy sets the stage for investigations into alternative fuels for automobiles. Reviewing physical and chemical changes in matter enables students to understand the complex processes used in converting potential energy into kinetic energy, and the dilemmas related to emissions from burning fossil fuels. This lesson provides students with the opportunity to explore fundamental concepts in Chemistry in the Community and the Transportation unit from Active Physics.

What Is Renewable Energy?

Summary

Students list the energy they use daily, then research the "fuel" used to generate that energy to learn which sources used in their own state are renewable and which are nonrenewable. From this, students are introduced to the challenges and issues raised around fuel consumption and alternative fuels.

The first part requires students to consider the concept of energy. They are challenged to differentiate between the phenomena and the transfer of energy from the source to the materials, objects, and tools they use — bulbs, heaters, radios, computers. The next step is for students to understand that electricity for their homes can be generated from different sources — fossil fuels, sunlight, wind, and water. Finally, students are challenged to consider the concept of renewable sources and finite or nonrenewable sources.

Background

High school students consume energy around the clock. Many do not think about the quantity they consume or their dependency on energy. Your students may not even be aware that there are different forms of energy, as well as different sources. Another concept your students may not have thought about, is that the same form of energy can be obtained from different sources. Each of these sources has costs to the consumer and to the environment. A major issue related to cost is that some sources are finite and can be depleted, while other sources are unlimited. The concept of energy held by many high school students is directly related to phenomena — light, heat, sound, and electricity. Some students will be able to state the fact that energy is conserved; that is, the total amount of energy is constant and cannot be "used up." Few however, will understand the underlying concept that the energy we use is obtained through transfer, and that the matter involved in the transfer steadily becomes less ordered. The matter almost always "becomes less ordered" to the extent it is no longer useable, or even recognizable. Examples of this are: the residual matter after burning fossil fuels, a "dead D-cell," or nuclear waste. Understanding of this concept develops over time and as a result of many experiences, discussions, and investigations.

The term "renewable energy" should be clarified with students — it is the source or fuel that is renewable. But what time span can be accepted as renewable? Are fossil fuels renewable? Is biomass renewable? This is a necessary discussion and is related to the issue of sustainability and cost. Many of your students will have had prior experiences with the concept of renewable sources of energy and may already have formed opinions about issues. It is important to accept all opinions without judgment during brainstorming sessions. It is equally important to make sure students know the difference between opinion and fact. During the presentation of facts gained through research, statements can and should be challenged and defended with references that have been verified.

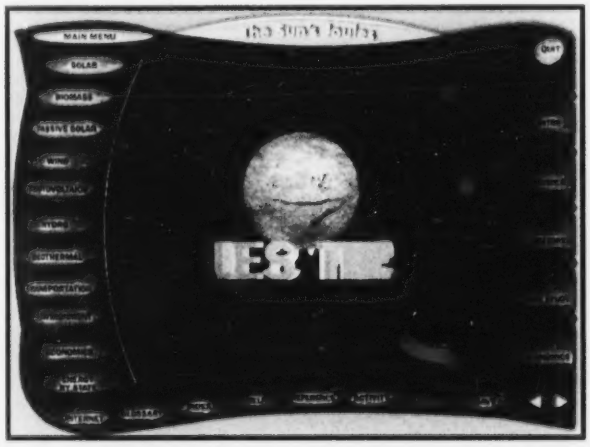
Teaching Strategy

1. Introduce the lesson by asking students to think of energy they have used so far in the day. Ask them to generate a list individually before collaborating in small groups.

2. Invite students to share their lists without discussion or critiques. Be prepared for the lists to contain a mix of energy forms and energy sources. After creating the class list, ask students to consider which are sources and which are forms. Rather than defining each term, begin with an example such as: Electricity is a form of energy; what is the source of the electricity that was used? Accept "unknown" as a valid response, with a note for later research.

3. Engage students in determining if the energy source is renewable or nonrenewable. When there are differences of opinion check the source to indicate it as a research topic. From this brainstorming should emerge student questions about how quickly the source can "renew" and the time span required before the source could be considered "renewable."

4. Assign topics to groups of students to research additional, or verify, stated information. List the following questions as starting points:
   - Where is the energy source or "fuel" obtained?
   - What is the technology that transfers or transforms the "fuel" into useable energy?
   - What is the time and cost required to obtain the "fuel"?
   - What is the time required for the fuel to "renew"?



5. Allow time for students to research the topics, either using *The Sun's Joules*, or with research tools available.

6. Websites that provide information are:

   DOE http://www.eren.doe.gov

   NREL http://nrel.gov

   CREST http://solstice.crest.org

7. After students present the results of their research, encourage them to add, delete, or correct information on the lists from steps 2 and 3.

8. Finally, ask students to reflect on what they have learned about sources of energy.

ACTIVITY 2

Why Do We Need Options?

Summary

Students research information about the decisions that resulted in the sources of fuel used in their own state, then compare percentages of energy obtained from each source among states with similar and different climates. Students are then challenged to apply this information in a debate or roleplay that reflects opposing points of view on potential changes in fuel sources.

The first part requires students to locate, organize, and analyze information about the fuels used to generate electricity and heat. From this, they develop an awareness that there is a wide range of resources used, and that the resources vary within and between states. Examining positions of various community members enables them to consider why these differences exist, and to propose explanations and arguments for increasing or decreasing use of each resource in their state.

Background

Every resource from which energy is obtained has costs to the consumer and to the environment. Those costs are not the same in all locations. Factors that affect cost to the consumer include the start-up cost of the technology, transportation of the fuel source, and cost of generating energy. The types of fuel sources used in each state are the result of these cost factors as well as factors related to geography, geology, politics, and society. This leads into the notion of tradeoffs. Is the impact on the region's environment sufficiently negative to warrant the cost of construction of a new facility? What is gained and what is lost? How are the gains and losses quantified? Can they be quantified?

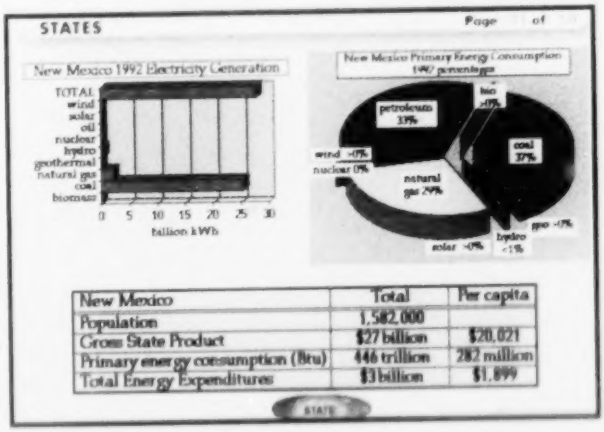
High school students can interpret and synthesize information in a manner that makes roleplaying a valuable tool for building understanding of the fact that all energy decisions have positive and negative factors. Considering the point of view of many people from a community or state allows these factors to be discussed without labeling some right and some wrong.

Teaching Strategy

1. Review with students the physics concepts related to changes in the matter from which energy is obtained. Ask them to generate a list of matter or fuel sources, from which energy is obtained, with a corresponding list of how the matter or fuel is affected.

2. Share the information from *The Sun's Joules* about the fuel sources used to obtain energy in your community and state. Ask students to consider how obtaining energy from the fuel changes it, and if the fuel is from a renewable resource.

3. Distribute data from other states. Ask students to compare both the geography and the geology of other states to yours. Challenge them to use this information to form an explanation of why the sources of energy are similar or different.



4. Have the class apply information about the sources of energy used in various states to formulate a proposal for replacing one of the sources used in your state with a renewable source.

5. Engage students in a discussion to generate questions about each fuel source used. Questions could relate to pollution, origin of the fuel source, age of the technology generating the energy, dependability or sustainability of the source, and environmental impacts.

6. Assign each pair of students a role to play in a community meeting about changing the fuel sources in the state. Possible roles and sample concerns include a research scientist concerned about global warming, a taxpayer concerned about state subsidies for construction of new technologies, merchants concerned about a change in the economy if a power plant closes, a health professional concerned about the effect of pollutants, a dairy farmer concerned about the effect of power lines, a railroad worker concerned about jobs lost due to less shipping of coal, and students who are concerned about losing a regional park.

7. Review strategies for researching: the newspapers, the Internet and *The Sun's Joules*.

8. After students have obtained enough information to represent the point of view assigned and to defend that point of view with facts, set up ground rules for the community meeting. Be sure to assign a city manager to moderate and several students to represent the media and write summaries of the discussions.

9. Conclude by having students reflect on the roles they played by identifying the tradeoffs involved in making a decision about change.

What Is Energy Efficiency?

Summary

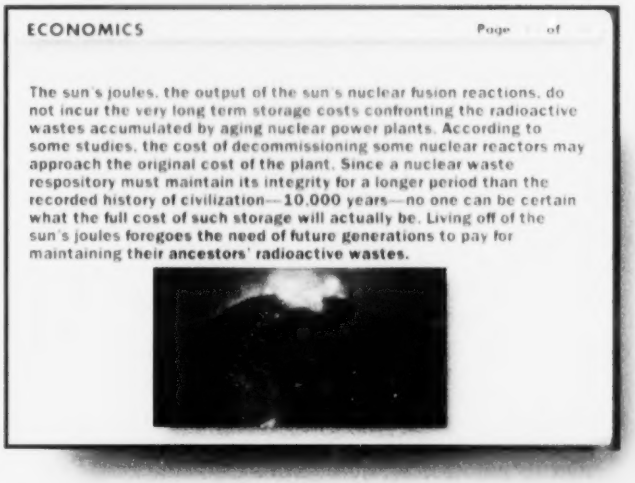
Students review units used to measure energy use, then investigate the rate at which their families utilize energy. They then use this information in a comparison study of the cost to produce energy, as compared to the percentage of useable power obtained. Finally they discuss how value can be determined.

The first part of this activity requires students to consider their own use of energy, with the emphasis on collecting and analyzing numerical data. After considering consumer costs and the costs of building the technology that transforms the energy into useable power, they reflect on how those costs compare to the efficiency of the technology and begin considering options that might appear to cost more, but are less costly over time.

Background

The term energy efficiency refers to the efficiency of the technology used to obtain energy. Efficiency is reported as the percent of potential energy that is obtained in a useable form. Current technologies have a great range in efficiencies. For example, superconducting wires are nearly 100 percent efficient. A compact fluorescent light bulb is nearly 3 times more efficient than a standard incandescent light bulb.

Cost effectiveness is another issue and is subjective, based on perceived value. The cost of the energy is determined by combining all costs related to obtaining the energy.— the cost of setting up the process, added to the cost of generating energy and the cost of delivering the energy to the consumer. Additional cost could include the cost of storing or cleaning up the waste produced.


ECONOMICS
Page of
The sun's joules, the output of the sun's nuclear fusion reactions, do not incur the very long term storage costs confronting the radioactive wastes accumulated by aging nuclear power plants. According to some studies, the cost of decommissioning some nuclear reactors may approach the original cost of the plant. Since a nuclear waste respository must maintain its integrity for a longer period than the recorded history of civilization—10,000 years—no one can be certain what the full cost of such storage will actually be. Living off of the sun's joules foregoes the need of future generations to pay for maintaining their ancestors' radioactive wastes.

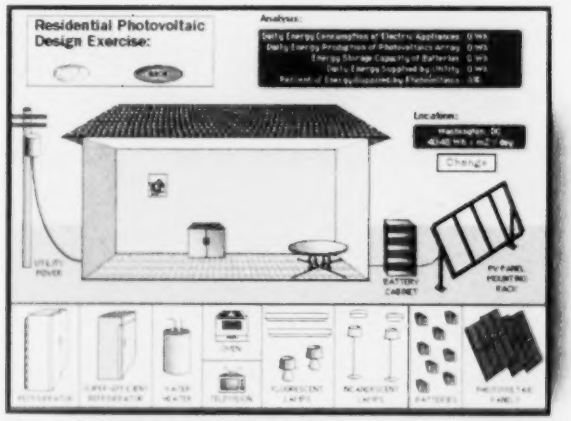
Teaching Strategy

1. Introduce the lesson by asking students to estimate the cost of the electricity they used over the past day, then the past week.

2. Share with students the information you obtain from your local power company with the cost per kilowatt of electricity. Also provide information from the company that gives sample charges for use of appliances. Allow students time to revise their estimates based on this new information.

3. Review units used to measure energy and power use. Engage students in using the interactive exercise on the cost of energy consumption found in *The Sun's Joules* section on Passive Solar.

4. Assign students homework to find out their family's most recent gas or electric bill. If possible, they should bring in information that includes kilowatts used as well as the charges. Statements from other times of year would also be useful.



5. After reviewing the cost of energy, invite students to form questions about how the utility company decides what to charge for the electricity.

6. Questions could include:

   - What is the age of the technology used to generate the power?
   - Where and how is the fuel obtained?
   - What is the cost of disposing of the waste or cleaning up any pollutants?
   - How much power is generated compared to waste products?

7. Involve students in using *The Sun's Joules* CD-ROM to research the efficiency of different sources of energy. They may also use the Internet and other resources available from local utility companies.

8. Encourage students to present the results of their research in a variety of formats including a mock press release, newspaper article, or public service announcement.

9. Finally, engage students in a discussion of how the best buy or most cost-effective source of energy can be determined.

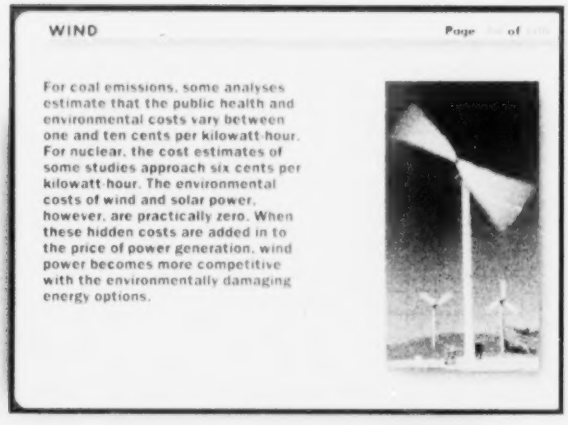
What Is the Environmental Cost of Energy?

Summary

Students present their ideas about the cost to the environment when energy is generated, then research the problems that are raised. After presenting results of their research, they discuss how renewable energy can provide solutions to the problems. The opening brainstorming allows students to begin with their own concepts and misconceptions about pollution and environmental issues. Discussing what is fact and what is opinion sets the stage for them to collect data, while analyzing the source of the data and considering the bias of the research. Reflecting on what they learn enables them to apply understanding of the issues to strategies for mitigating impact of their own future use of energy.

Background

There is a close connection between pollution and the production and consumption of energy. Generating electricity and other forms of energy has direct and indirect costs to the environment. The cost of pollution is obvious: air pollution is directly related to an increase in lung disease, asthma, and heart conditions. Other direct costs include loss of fish habitat in rivers polluted by industrial waste. Indirect costs result from additional activities companies must perform: for example, handling, storage, and disposal of discharges. What will be the long-term effect on the environment of storing nuclear waste? Will the chemicals used to clean up an oil spill cause unforeseen problems to future generations?


WIND

Page of

For coal emissions, some analyses estimate that the public health and environmental costs vary between one and ten cents per kilowatt-hour. For nuclear, the cost estimates of some studies approach six cents per kilowatt-hour. The environmental costs of wind and solar power, however, are practically zero. When these hidden costs are added in to the price of power generation, wind power becomes more competitive with the environmentally damaging energy options.

Another environmental cost is depletion of resources due to inefficient technologies. When residual matter, harmful substances, or other energy forms are discharged into the environment as pollution, it is a sign that resources have been used incompletely, inefficiently, or ineffectively. The concept of depletion also applies to the wildlife, forests, and water systems that are decreasing due to environmental changes resulting from energy production and consumption.

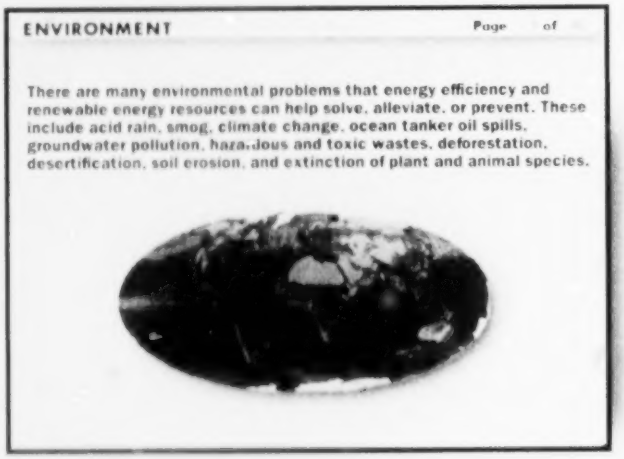
The source of a pollutant or environmental problem is sometimes hard to identify. Point source pollution, or pollution which can be traced to a specific cause, is much easier to address with clean-up efforts and change in technologies. Unfortunately, many of our national and global problems are not point specific.

Teaching Strategy

1. Introduce the lesson by asking students to list examples they have encountered of the environmental impact of energy. As this can be an emotional topic, direct students to share their lists without discussion or critiques.

2. After creating a class list, ask students to consider which examples can be supported by fact. Which are now only supported by opinion? The Teaching Standards and the Nature of Science Standards found in the National Science Education Standards should guide this discussion.

3. Use an overhead or large screen monitor to show students *The Sun's Joules* Environment, slide 3.


ENVIRONMENT
Page of
There are many environmental problems that energy efficiency and renewable energy resources can help solve, alleviate, or prevent. These include acid rain, smog, climate change, ocean tanker oil spills, groundwater pollution, hazardous and toxic wastes, deforestation, desertification, soil erosion, and extinction of plant and animal species.

4. Allow students to choose their own environmental problem to research for presentation to the class. Establish criteria such as the following:
   - What is the international scope of the problem?
   - What is the extent of this problem in the United States? In your own state?
   - What research has been done to determine the cause?
   - What alternative sources for energy have been developed that can greatly reduce the impact of this problem?

5. Allow time for students to research the topics, either using *The Sun's Joules*, or with research tools available in your school.

6. After students present the results of their research, encourage them to apply what they have learned by writing a summary of the problem and how a renewable resource will help alleviate the problem.

7. Finally, ask students to reflect on what they have learned about the cost on the environment of their own energy use. How can any of the information gained from this activity inform their decisions regarding energy consumption?

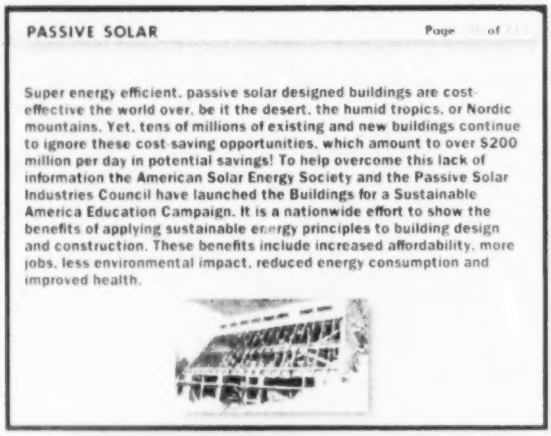
How Can Passive Solar Be Used in Home Construction?

Summary

Students first complete an experiment from Active Physics. Home in which they collect data on the rate of temperature increase inside a cardboard home they have designed and constructed. Discussing peak temperature leads them to research passive solar technologies they can use to make their home cooler in the summer while maintaining heat on colder days. This lesson provides students with an opportunity to apply the data they have collected to a design technology problem: Is there a universal design for homes that can be built in any environment?

Background

Around most city buildings are dark surfaces and less vegetation, which affect climate, increase energy use, and decrease habitability. Buildings' dark roofs and inadequate shade in summertime raise the demand for air-conditioning, so more power and pollution are generated. The sun's radiation on unprotected blocks of buildings can raise the temperature of many cities by as much as five degrees, increasing the production of smog, which is typically created in hot weather. Finally, urban heat islands exacerbate all heat waves, contributing to fatalities.


PASSIVE SOLAR Page [illegible] of [illegible]

Super energy efficient, passive solar designed buildings are cost-effective the world over, be it the desert, the humid tropics, or Nordic mountains. Yet, tens of millions of existing and new buildings continue to ignore these cost-saving opportunities, which amount to over $200 million per day in potential savings! To help overcome this lack of information the American Solar Energy Society and the Passive Solar Industries Council have launched the Buildings for a Sustainable America Education Campaign. It is a nationwide effort to show the benefits of applying sustainable energy principles to building design and construction. These benefits include increased affordability, more jobs, less environmental impact, reduced energy consumption and improved health.

In the Home unit, students begin Chapter 1 with a challenge to design and construct a universal dwelling that maximizes space while minimizing cost of construction materials. The second part of the challenge is to modify the dwelling with insulation, awnings, or other structural changes to prevent heat loss in colder climates and excessive interior heat in warmer climates. Buildings can also use shade trees and light-colored surfaces to reduce the impact of the sun on interior temperatures.

Buildings that take advantage of passive solar heating and cooling must rely on a diverse range of science concepts, engineering practices, and architectural designs. The strategies for preventing excess solar radiation during hot summers are not the same strategies for maximizing solar radiation for heat in the winter. Students need an opportunity to explore the concept of a universal dwelling before accepting that knowledge and understanding of the environment is a critical factor in constructing energy-efficient buildings.

Teaching Strategy

1. After students have obtained data from the heat probes, ask them to think about how comfortable they would be living in a home that reached those internal temperatures. What would they want to change about the temperature?

2. Invite students to discuss their ideas within their group, using their home design as they explore possible modifications.

3. Allow students time to research the use of passive solar in the design and construction of a home.

4. Before students apply new ideas to plan modifications, discuss possible ways to allow creative adaptations to the use of cardboard as the building material. Possible ideas you could suggest to initiate brainstorming are:

   - Cover the outside of the cardboard with a mud version of adobe.
   - Use plants to make a thatch roof.
   - Place the entire house inside a dirt-filled terrarium.

NREL PIX 04150

PV house

5. After students have modified the design and the construction of their homes, remind them to repeat the heat experiment, recording and graphing data collected.

6. Work as a class to devise a way to test these newly redesigned homes for their ability to retain heat when in a cold setting. Establish parameters for implementing this investigation, including a strategy for determining efficiency.

7. Hold a discussion in which students compare the way in which each home design insulated against high temperatures and how it held heat when subjected to cold.

8. Finally, ask students to reflect on what they have learned by writing a statement about the feasibility of creating a universal home design.

ACTIVITY 6

How Can Motor Vehicles Use Renewable Energy?

Summary

After investigating fuel economy as related to vehicle weight, engine size, and power use, students are challenged to research technologies that use alternatives to petroleum for renewable sources to produce fuel for automobiles. They also investigate the use of solar power for vehicles. Through this, they also review the difference between energy transfer and the chemical changes involved in energy transformation. Reviewing physical and chemical changes in matter enables them to understand the complex processes used in converting potential energy into kinetic energy, and the dilemmas related to emissions from burning fossil fuels.

Background

Americans, who comprise only one-twentieth of the world's population, own more cars per person, travel more miles per car, and consume about one-sixth of the world's oil. Each car in the United States produces its weight in carbon emissions each year. U.S. emissions of carbon dioxide are considered the chief cause of global warming. Increasing fuel efficiency and developing technologies to reduce emissions is crucial for alleviating air pollution.

The chemical reactions resulting from the heat in an internal combustion engine releases carbon dioxide, carbon monoxide, nitrogen oxides, sulfur oxides, and volatile organic compounds. Obtaining energy through chemical reactions is the process of energy transformation. One of the most common misconceptions of students about physical science is the difference between energy transfer and energy transformation.

New technologies are improving the efficiency of fuel cells, which are able to convert or transform chemical energy directly into electricity without combustion. Fuels for these cells come from hydrogen-based biomass fuels and natural gas. Eliminating the burning improves efficiency and greatly decreases air pollution. The fuels from biomass produce almost 90 percent less pollution than gasoline and 25 percent less pollution than natural gas. Vehicles powered with solar cells, which transform energy from the sun to electricity, release virtually no pollution. In addition, high use of petroleum fueled vehicles makes the U.S. dependent upon foreign oil. The first big effort to utilize non-petroleum products for fueling automobiles occurred in the 1970s as a result of the Middle East oil embargo.

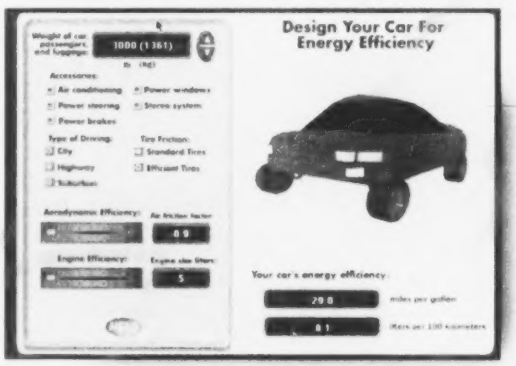
The high cost and low efficiency of the technology used then made gasohol less than ideal choice. However, over the past twenty years, research and development has continued, as well as efforts to educate Americans on how changes in lifestyle and work habits can decrease pollution and dependency on petroleum.

Teaching Strategy

1. Using resources from car dealerships and magazines such as *Consumer Reports*, *Car and Driver*, or *Road and Track*, engage students in finding the range of miles per gallon obtained by a variety of types and sizes of vehicles.

2. Discuss features of these vehicles, including weight, size of the engine, and power options. Then, ask students to apply this information to form generalizations that relate miles per gallon to these features.

3. Either in small groups or as a class, engage students in the Transportation interactive exercise on *The Sun's Joules*.



4. Invite students to share their thoughts, reactions, or any questions they have as a result of the exercise.

5. Show an enlarged copy of the slide, (Transportation page 94), then review the chemical changes involved when a vehicle's internal combustion engine burns gasoline. Depending on the course syllabus and students' background, include time to focus on differences between energy transfer and energy transformation. Remind students that it is the process of chemical change that results in the greatest amount of polluting by products.

6. Challenge students to consider the following statement, adapted from *The Sun's Joules*, Transportation pages 11 and 12.

7. There are four ways to improve our mobile lifestyles on the planet:

   - Improve land uses so that homes, work, shopping, and recreational needs are conveniently located, allowing options like walking, bicycles, and mass transit.
   - Increase fuel efficiency of vehicles.
   - Shift to superior clean energy resources, ultimately to renewable generated fuels such as hydrogen, the use of fuel cells, and solar power.
   - Find non-mobile ways of deriving recreational activities.

8. Allow students to select one of the four topics to research, making sure that at least one student selects each option within the topic. Encourage them to use multiple resources, including *The Sun's Joules*, to obtain pros and cons to each alternative.

9. Encourage creativity in presentations of results. An editorial or debate might provide a forum for your students to share information with others in your school.

The Sun's Joules Energy Education Program Guide

The Sun's Joules Energy Education Program Guide, which accompanies the Educational Edition of the CD-ROM, provides teachers with learner-centered strategies for implementing a multidisciplinary unit on renewable energy. The guide also includes suggestions teachers may use to develop or enhance their own energy education units.

Entitled the China Dilemma, this unit engages students in investigating costs and benefits of alternates to the planned The Three Gorges dam on China's Yangztee River. This large-scale hydroelectric dam would supply a significant source of much-needed electrical power, but at a great cost to the existing communities and the environment. The resulting 392-mile reservoir will submerge thousands of villages and displace more than a million people. Environmental issues include loss of farmland, erosion, and the destruction of habitat for already endangered species. Through roleplaying and examining tradeoffs, students have the opportunity to apply accurate information to a real situation

Workshops and Professional Development Opportunities

Assistance in implementing *The Sun's Joules* Energy Education Program is also available. McREL has developed two professional development workshops. A full day workshop was developed for classroom teachers that focuses on how to use *The Sun's Joules* CD-ROM in a manner that enhances student learning and problem solving skills. This workshop begins with the China Dilemma and concludes with a state challenge that encourages students to transfer what they learned from the China Dilemma to a local energy issue. Incorporated into this workshop are discussions on additional ways teachers can use the CD-ROM to meet instructional goals.

Professional development that focuses on best educational practices while using CD-ROM technology in a learner-centered classroom is the goal of the two day workshop available from McREL. This workshop, designed for those who provide professional development, uses *The Sun's Joules* as the vehicle for learning how to facilitate instruction with technology. In the workshop, emphasis is given to constructivist learning theories, problem based learning, the teacher as facilitator, and the integration of standards in the design of multidisciplinary units

Contact The Learning Team for more information or to schedule a workshop at *(914) 273-2226*

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